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translator to RWS Group plc, of Europa House, Marsham Way, Gerrards Cross, Buckinghamshire, England declare;

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2. That I am well acquainted with the German and English languages.

3. That the attached is, to the best of my knowledge and belief, a true translation into the English language of the accompanying copy of the specification filed with the application for a patent in Germany on 4 September 1995 under the number 295 14 164.6 and the official certificate attached hereto.

4. That I believe that all statements made herein of my own knowledge are true and that all statements made on information and belief are true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the patent application in the United States of America or any patent issuing thereon.

For and on behalf of RWS Group plc

The 24th day of October 2003

FEDERAL REPUBLIC OF GERMANY

[Eagle crest]

Priority Certificate
for the filing of a Patent Application

File Reference:	295 14 164.6
Filing date:	4 September 1995
Applicant/Proprietor:	Dipl.-Ing. Alfred E b b i n g h a u s , Aalen/DE
Title:	Foam-filled shaped part
IPC:	C 22 C 1/08

The attached documents are a correct and accurate reproduction of the original submission for this Application.

Munich, 8 October 2003
German Patent and Trademark Office
The President
pp

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[signature]
Scholz

Description

The invention relates to foam-filled shaped parts, in particular at least partially hollow shaped parts, with longitudinal and/or cross sections which may differ in shape and/or size, having a hollow outer form and a filling comprising an open-cell or closed-cell foam.

Support elements made from solid or hollow material, such as tubes, rods, hollow beams (for example support parts for bicycles, automobile rear axles, exhaust pipes, etc. produced by means of the hydroforming process) are known for a very wide range of application areas, for example for construction work, in particular bridges or houses - as supporting and bearing elements, or also for the construction of aircraft, vehicles and vessels, shelving systems and the like.

In this case, the outer shaped part and also the foam filling may be in single-part or multipart form, comprising one or more materials.

They have the advantage, inter alia, of allowing a lightweight structure which is nevertheless able to withstand loads.

By way of example, in motor vehicles tubular space frames have recently been used again to save weight, in order to allow an especially lightweight, strong and torsionally rigid design. A framework structure with hollow or solid framework bearing parts has often also been used in aircraft, in which weight savings constitute a major focal point in design.

The known bearing structures and parts were still capable of improvement, since it is always desirable for them to be made even stronger, in particular with a better buckling strength.

A further drawback was that it was still always necessary to use considerable wall thicknesses for load-bearing hollow parts, leading to undesirably high weights of the part, in particular if a high buckling strength or load-bearing capacity was desired.

By contrast, it is an object of the invention to produce lightweight components which are more lightweight and/or more resistant to corrosion than known individual components while achieving identical or better load-bearing properties.

According to the invention, the object is achieved by a foam-filled shaped part, in particular an at least partially hollow shaped part, with longitudinal and/or cross sections which may differ in shape and/or size, having a hollow outer form and a filling comprising an open-cell or closed-cell foam.

The hollow outer shaped part used in this case may be hollow shaped parts which are known per se, such as seamless or welded tubes or other known profiled sections, although it is also possible for shaped parts of this type to be produced specially and to be designed to match the specific requirements. Suitable materials for this outer shaped part are metals, or alternatively plastics, enclosed ceramics.

For strength reasons, it is advantageous if the fiber profile of the material of the outer form runs substantially parallel to the outer contours of the shaped part, as is possible, for example, if the outer shaped part is produced using the known hydroforming process. The person skilled in the art will then be familiar with the appropriate cold-formable materials for this process.

In this context, it may be expedient for the outer shaped part to include a plurality of layers which run

parallel to one another, rest on top of one another, are made from identical or different materials and the fiber profiles of which are parallel to one another.

In particular with a view to saving weight, it is possible for the entire component to substantially comprise the same or different light metals. By way of example, the light metal may be aluminum or an alloy thereof, which can also give a good resistance to corrosion.

It is possible and in many applications desirable for the component to include fiber-reinforced materials, which combine a high mechanical load-bearing capacity with a light weight.

The component may have different longitudinal sections and different cross sections.

It may be advantageous for the individual components of the foam-filled shaped part to consist of different materials, such as for example metal/ceramic; metal/plastic foam; metal foam/plastic outer wall, etc.

It may be expedient for at least one hollow part to have recesses and/or openings formed in it.

An advantageous process for producing hollow shaped parts as claimed in one of the preceding claims [sic], in which a hollow outer form is produced in a manner which is known per se by drawing, casting, extrusion, hydroforming, and is then filled with foam formed from the foam starting material.

However, it is also possible for the foam to be foamed separately in a mold and then introduced into the finished outer shaped part by means of a shrinking process or the like, in which context it should be

ensured that there is no separation of the materials under the expected operating conditions.

The production of plastic foams is a standard and known process, whereas the production of metal foams has recently become possible, for example by a blowing agent/metal mixture being foamed in a manner known per se in the hollow outer form (cf. Studiengesellschaft Stahlanwendung e.V. Forschung für die Praxis; P 286 - Prospektive Marktstudie zur Anwendung von Stahlschäumen [Prospective marketing study on the use of steel foams] by Dipl.-Ing. Markus Weber, Verlag und Vertriebgsgesellschaft mbH, Düsseldorf 1995.)

The metal foam may, for example, be a steel or aluminum foam or any foam selected on the basis of the requirements and intended use of the hollow part.

By way of example, it may be appropriate for the foam filling to be a closed-cell plastic filling if the intention is primarily to damp vibrations or prevent corrosion in the hollow space.

However, it may also be expedient for the foam filling to be a metal foam, for example if it is to be exposed to high temperatures or is intended to support/stabilize the outer shaped part. Moreover, filling the outer shaped part with foam improves the elastic characteristics of the outer walls and also the thermal and acoustic insulation.

A preferred process for producing the component according to the invention includes the following steps:

provision of a hollow part, if appropriate with different diameters;

introduction of a hollow-part section into a die, with widening in the deformation region;

application of an internal high pressure to the tube, so that the tube wall is widened in the region of the die widening;

removal of the in [sic] deformed hollow part with widened sections and if appropriate introduction of a foam starting mixture comprising foamable material and blowing agent into the hollow part and activation of the blowing agent, so that the expanding foam fills the hollow part.

However, it is also possible for the foamed part to be produced separately from the hollow part - for example in a foaming mold - and for the sponge-like structure then to be introduced into the hollow part, for example by a shrinking process or after thermal widening of the hollow part.

However, depending on the material used for the foam, it is also possible for the material formed from powder with incorporated blowing agent or in the liquid phase to be introduced into the hollow part and then to form a foam from it, in order for the foam to be optimally matched to the shape of the hollow shaped part.

The hydroforming process referred to above is understood in the present context as meaning the process which is described, for example, in Industrieanzeiger No. 20 of 03.09.1984 or in "Metallumformtechnik" [Metal forming technology], Edition 1D/91, pages 15 ff.: A. Ebbinghaus: Präzisionswerkstücke in Leichtbauweise, hergestellt durch Innenhochdruckumformen" [Precision workpieces of lightweight design produced by hydroforming], or Werkstoff und Betrieb 123 (1990), 3, pages 241 to 243: A. Ebbinghaus: "Wirtschaftliches Konstruieren mit innenhochdruckumgeformten Präzisionswerkstücken [Economic design with hydroformed precision workpieces]

or "Werkstoff und Betrieb 122, (1991), 11, (1989), pages 933 to 938. To avoid repetition, the text which follows incorporates the disclosure of these documents in their entirety by reference. This process has hitherto been used for the production of various shaped hollow parts, such as and/or [sic] for the production of constructed camshafts for attaching cams to a tube, for producing hollow camshafts, and also for producing motor vehicle frame parts.

Surprisingly, this hydroforming process makes it possible to form completely new types of hollow metal components, in which the fiber profile in the region of the walls runs substantially parallel to the outer contour without kinks or other weakened sections being present. Accordingly, these hollow shaped parts can be designed in more lightweight form than previously, on account of the high wall strength brought about by the favorable fiber profile and the reinforcement from the internal foam filling, thus allowing a considerable saving on weight. It is also possible for laminated materials to be used for the outer form, provided that they can be jointly deformed. As a result of suitable materials being selected, laminates can be more lightweight than solid materials and also have the advantage of having a vibration-damping action, and may also have further layers at the surfaces according to the environmental conditions (corrosion caused by acids, etc.) or for esthetic reasons (coloring), so that a part of this nature also has favorable vibration-damping properties, since the foam filling, depending on the material, bears elastically against the outer walls, i.e. the materials are subject to less load from oscillations.

However, it is also possible to select a multilayer metal tube as the starting part, depending on the demands imposed on the material. In this case, multilayer configurations have the advantage of

different load-bearing capacity of the surfaces of the hollow part and also of being less likely to transmit oscillations of all types, which decisively improves the vibration behavior of the hollow part in use. However, it is also possible to provide a metal foam in a plastic tube, in particular if the plastic outer layer is desired for corrosion reasons or other reasons, for example on account of the lubricating properties of the plastic or the like.

Advantageous uses of the part according to the invention include vehicles, aircraft and vessels, bicycle, motorcycle and automobile frames, construction and civil engineering, scaffolding, shelving systems, furniture.

Its use is recommended in particular in all lightweight construction application areas.

On account of the fact that foam-filled hollow parts which are as far as possible closed up in accordance with the invention are used as components, it is possible to allow extremely lightweight yet strong and vibration-damped components.

By virtue of the fact that a hydroforming process is used, it is possible for elevations and recesses, openings and the like to be produced on the outer hollow part as early as during a shaping operation. This makes it possible to reduce subsequent treatment steps.

A very wide range of hollow outer shaped parts, specifically including rectangular profiled sections, angled profiled sections, tubes, etc., can be used as hollow parts.

The result is a part with a weight which is lower than that of previous parts yet with the same load-bearing

capacity or a higher load-bearing capacity with a low weight which can still be produced with a high level of production accuracy and a reduced scrap rate.

The invention is to be explained in more detail below with reference to the appended drawing, in which:

Figure 1 shows a diagrammatic, perspective illustration of part of a component according to the invention with a closed-cell foam;

Figure 2 shows a longitudinal section through the component shown in Fig. 1;

Figure 3 shows the component shown in Fig. 1 in cross section on line A-A in Fig. 1;

Figure 4 shows a cross section through a component according to the invention with an open-cell foam, and

Figure 5 shows a cross section through a component according to the invention with multilayer outer walls.

As can be seen from Figs. 1, 2 and 3, which each show the same component (automobile axle bearer made from aluminum alloy), the component comprises an outer wall 12 and the foam filling 14 (both in this case made from aluminum alloy). The outer shaped part has been three-dimensionally formed by means of the hydroforming process, in order, for example, to be used as part of a multi-link suspension.

It should be noted that desired compression locations can be formed into the parts produced by the forming process - the outer wall - by means of targeted integrally formed grooves, for example in order to absorb energy by controlled deformation in vehicles in the event of an accident, or alternatively it is also possible to incorporate reinforcing profiles, for

example by forming longitudinal ribs (passenger compartment).

The hollow outer shaped parts may have different diameters over their longitudinal extent, as well as different cross sections.

Fig. 4 shows a detailed view of another form of application of a part according to the invention. This is a support body for motor vehicle catalytic converters, which includes an open-cell steel foam in a steel outer casing. In this embodiment, the problem of connecting the housing to the support body and the problem of producing gas passages which are then coated with the catalyst, which are generally known for this type of support bodies, are eliminated altogether, since the fact that for the first time it is now possible to use the same material for housing and gas-flow body (often also referred to as the honeycomb body) means that it is possible to avoid stresses in the catalytic converter support body caused by the different expansion coefficients of the materials used for the support body, which have hitherto restricted the service life of this body.

Fig. 5 illustrates a further embodiment of a component according to the invention with a finned tube, with the multi-walled outer form having a foam filling.

In this case, the hollow outer shaped parts may consist either of a single material, for example steel or a light metal alloy, or, depending on the process of use, it is also possible to deform laminate material, including plastic-coated or covered tubes/hollow parts, depending on the intended application.

The provision of suitable layers makes it possible to achieve resistance to corrosion or a coloring without further working steps being required.

In particular, foam-filling with closed-cell foams makes it possible to achieve a high resistance to corrosion, since it is impossible for any corrosive material to gain access through the closed-cell foam.

As is known, guiding material along the tube longitudinal axes during deformation so as to follow the deformation, for example using movable molding elements, makes it possible to achieve a substantially constant wall thickness in the outer form, so that it is possible to at least partially compensate for weakening of the wall thickness of the outer form caused by the integral formation of elevations, so that elevations are formed integrally without weakening.

Therefore, the configuration in accordance with the invention creates a stronger, more lightweight support material than has hitherto been possible.

Further configurations and developments within the scope of protection of the claims will be obvious to the person skilled in the art, and the scope of protection is in no way limited to the embodiments given here by way of example, which are intended merely to serve as an explanation.

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PATENT & LEGAL ATTORNEYS

To the
German Patent Office

80297 Munich

New application 09.04.1995
Our ref.: EBB0195GM

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Foam-filled shaped part

Claims

1. A foam-filled shaped part with longitudinal and/or cross sections which may differ in shape and/or size, having a hollow, single-part or multipart outer shaped part (12) and a filling comprising an open-cell or closed-cell foam (14), which at least partially fills the internal cavity in the hollow outer shaped part (12).

2. The shaped part as claimed in claim 1, wherein the fiber profile of the material of the outer shaped part (12) runs substantially parallel to the outer contours.

3. The shaped part as claimed in claim 1 or 2, wherein the outer shaped part (12) includes a plurality of layers which run parallel to one another, rest on top of one another, are made from identical or

different materials and the fiber profiles of which are parallel to one another.

4. The shaped part as claimed in one of the preceding claims, wherein the materials of the outer shaped part (12) include one or more - if appropriate jointly deformed - layers of cold-formable material.

5. The shaped part as claimed in one of the preceding claims, wherein the cold-formable material is a metal.

6. The shaped part as claimed in one of the preceding claims, which at least partially comprises steel.

7. The shaped part as claimed in one of claims 1 to 4, which is at least in part made from a light metal, aluminum, titanium or an alloy thereof.

8. The shaped part as claimed in one of the preceding claims, which includes fiber-reinforced materials in the outer shaped part (12).

9. The shaped part as claimed in one of the preceding claims, wherein the foam filling (14) is a plastic foam or a metal foam.

10. A shaped part, wherein the metal foam (14) is a steel foam or aluminum foam.

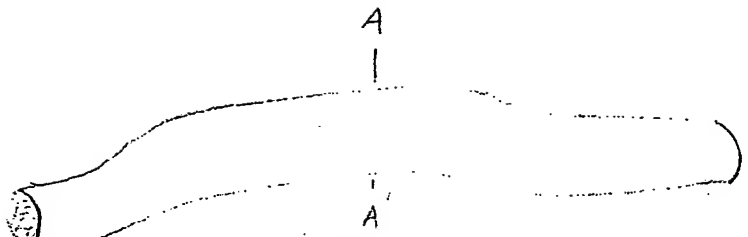

FIG. 1

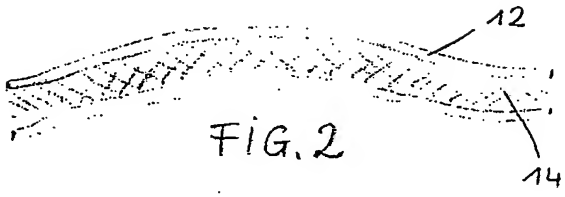

FIG. 2

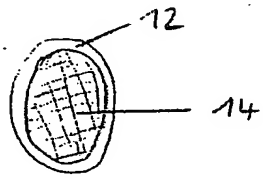

FIG. 3

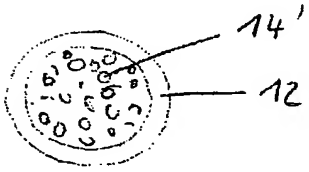

FIG. 4

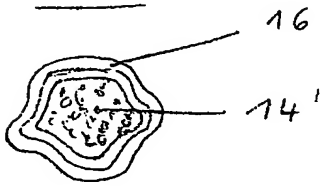

FIG. 5